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Overview of Idaho National Laboratory's Hot Fuels Examination Facility

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Abstract

The Hot Fuels Examination Facility (HFEF) at the Materials and Fuels Complex (MFC) of the Idaho National Laboratory was constructed in the 1960's and opened for operation in the 1975 in support of the liquid metal fast breeder reactor research. Specifically the facility was designed to handle spent fuel and irradiated experiments from the Experimental Breeder Reactor EBRII, the Fast Flux Test Facility (FFTF), and the Transient Reactor Test Facility (TREAT). HFEF is a large alpha-gamma facility designed to remotely characterize highly radioactive materials. In the late 1980's the facility also began support of the US DOE waste characterization including characterizing contact-handled transuranic (CH-TRU) waste. A description of the hot cell as well as some of its primary capabilities are discussed herein.

Keywords

Hot Fuels Examination Facility, Idaho National Laboratory, Materials and Fuels Complex

1.0 <u>Introduction</u>

The hot fuels examination facility (HFEF) located at the Materials and Fuels Complex of Idaho National Laboratory was made operational in 1975. Its original purpose was to support the Liquid Metal Fast Breeder Reactor Program with both post and interim irradiation exams. It is a large (200 square meters) alpha/gamma cell with an inert argon atmosphere. It is coupled with a smaller (55 square meters) decon cell which is air filled. The two are connected through various size ports. The facility is also equipped with a 250 kW TRIGA reactor which is used for neutron radiography. Over the past 30 years the facility has adapted from fast reactor irradiation exams and now is used in support of irradiation of hundreds of fuels and materials for many different programs. In the late nineteen eighties it was agreed that HFEF would also provide support in waste characterization to assist in the licensing of the Waste Isolation Plant (WIPP) destined for New Mexico.

2.0 <u>Brief Overview of Facility Capabilities</u>

A brief description of some of the components and capabilities of HFEF are included here. This includes the main cell, decon cell, and post irradiation equipment

2.1 <u>Main Cell</u>

The main cell is 22 meters long by 9 meters wide and 8 feet high and contains an argon atmosphere. The atmosphere is kept at about 60 ppm oxygen and moisture. There are 2.5-meter deep storage spaces underneath removable flooring, which are typically used to store fuel elements before and between exams. There are also two, 1-meter diameter by thirty feet deep pits, which are available for storage of long items such as test loops.

The cell has two electro-mechanical manipulators that are each capable of handling 750 lbs. There are also 2 cranes, which are each capable of handling 5 tons. The cell also has 15 workstations, each equipped with two master/slave manipulators most rated for 20 lb vertical lifts. There are 5 primary penetrations into the cell that are currently used. They are described in table 1.

Table 1 Main Cell Transfer Ports

Penetration	Size
Large Lock	6 ft. diameter by 12 ft. long
Small Lock	12 in. wide by 18 in. high by 60 in. long
Rapid Insertion Port (2)	3 in. by 18 in.
Cask Tunnel Transfer Penetration	21 9/16 in. ID
Loop Insertion Cell (roof penetration)	25 in. ID

Within the main cell is equipment designed for the waste form development program. Argonne National Laboratory developed an electrometallurgical process for treating spent fuel from the Experimental Breeder Reactor II (EBR-II). From that process (performed in another facility) come two waste forms, a ceramic waste and a metallic waste. HFEF has been involved with the characterization of these wastes and has investigated them for geological disposal. The equipment involved in that program includes a very large v-mixer, a Hot Isostatic Press (HIP), and associated equipment. The waste was treated, examined, and characterized all within the facility.

2.2 Decon Cell

The decon cell is an air filled cell that is 9 meters wide by 6 meters long by 7.5 meters high. There is no under floor storage similar to the main cell, but there are 3 pits which are 40 centimeters diameter by 3 meters deep. The cell is supported by one 750 lb electro-mechanical manipulator, one 5-ton crane, and 6 sets of master/slave manipulators. The decon cell has a large high spray chamber for decontaminating equipment. A hand held wand is capable of spraying either water or steam. Equipment being decontaminated is placed on a 5-ton turntable, which can be rotated to facilitate cleaning. Directly above the decon cell is the hot repair area. This room is used for contact maintenance on hot cell equipment and master/slave manipulators.

2.3 Post Irradiation Examinations

HFEF was designed to perform non-destructive examinations of fuel elements. The typical exams and related equipment are shown in table 2.

Table 2 Non Destructive Exams and Equipment

Non-Destructive Exams	Equipment Used
Neutron Radiography	250 kW TRIGA reactor
Element/Capsule Diameter	Element Contact Profilometer
Element/Capsule Gas Sampling	Gas Assay Sample and Recharge
Element/Capsule Weight	Balance
Fission and Activation Product Distribution	Precision Gamma Scanner
Element Bowing and Length	Bow and Length machine
Macro Photography	High Resolution Digital Photography
High Precision Specific Gravity	Pycnometer
Plate Fuel Thickness Measurement	Micrometer and Stand
Plate Oxide Thickness Measurement	Eddy Current Probe and Stand

The neutron radiography utilizes an indirect radiography process in order to prevent darkening of the x-ray film from highly radioactive samples. Indium and dysprosium are used as neutron detection foils and are then placed in a film cassette where they are allowed to decay against the x-ray film. The neutron diffraction equipment is capable of holding samples up to 152 inches long, 6.5 inches in diameter and up to 600 lbs.

The precision gamma scanner is used to find relative fuel burn-up and power profiles within fuel elements. It utilizes a high purity germanium detector surrounded by a sodium iodide crystal to reduce Compton background, a precision motorized stage capable of 4 degrees of freedom (x,y,z and rotation), and computer processing equipment.

The Gas Assay Sample and Recharge (GASR) has the ability to puncture cylindrical capsules or fuel elements and sample for gas composition, pressure, and volume. After sampling, the GASR has the ability to refill the plenum with any gas desired and weld the capsule closed. Volume and pressure measurements are accurate to ±5% and are capable of volumes of 0.03 to 60 liters.

An eddy current probe adapted for hot cell use is used for finding oxide layer thickness on fuel plates. It has been shown to be accurate to +/- 0.5 μm when the substrate is flat, the oxide layer is uniform, and the probe is perpendicular to the plate surface. Figure 1 shows the eddy current probe fitted for measuring flat plates with measurements in columns of three.

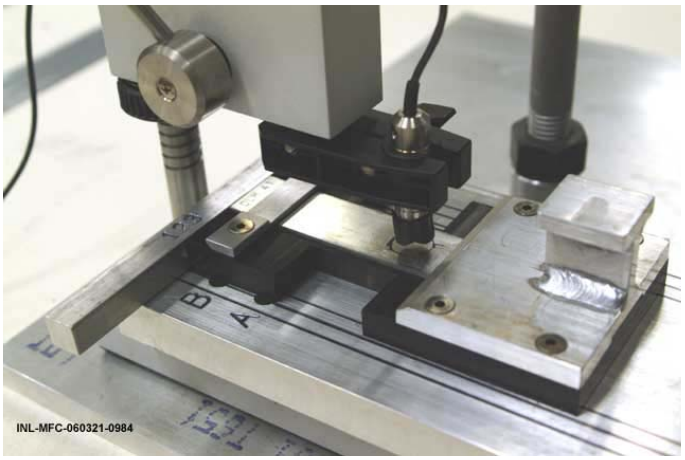

Figure 1 Eddy current probe for measuring oxide layer thickness

HFEF has also expanded its destructive examination equipment in order to help with characterization of irradiated materials and fuels. Typical equipment such as low speed saws, grinders, and polishers have been adapted for hot cell use and are utilized for sample preparation. A Leitz metallograph is located in a hot cell adjacent to the main cell. Samples can be prepped in the main cell containment box and transferred via pneumatic rabbit system for optical microscopy. Specialty mounts are fabricated using mycarta depending on the size and shape of samples. A new micro-hardness tester is in process of installation into the same cell as the metallograph. This will help with characterizing structural changes in spent fuel and irradiated materials as well as provide additional optical metallography capabilities.

A standard, commercially available punch has been adapted for hot cell use and is used to make 1 mm diameter punches for analysis in an unshielded scanning electron microscope. Samples are punched from a plate and directly into a collection tube where they can be sealed and transferred to another laboratory for sample preparation. Figure 2 shows the SEM punch schematic.

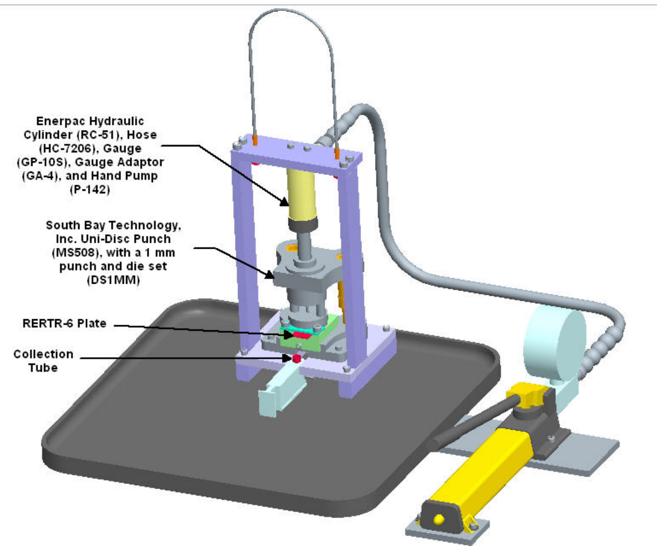

Figure 2 SEM punch

Dimensional analysis on plate fuel has been performed using a plate stand equipped with a micrometer. The stand is equipped with set stops so that repeatable measurements can be taken. Figure 3 shows the setup in mock up before being placed in the cell. The stand is capable of having both x and y stops.

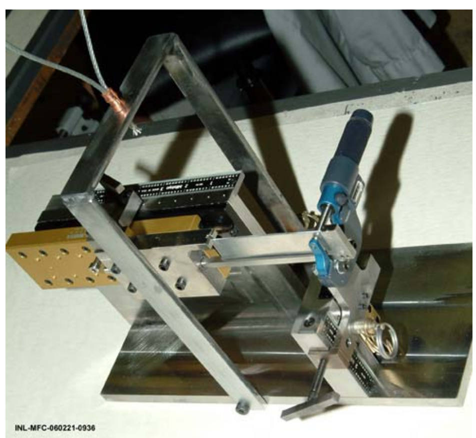

Figure 3 Thickness measurement device

3.0 Conclusions

The hot fuels examination facility at Idaho National Laboratory is a fully capable of both non-destructive and destructive exams of irradiated fuels and materials. The facility has grown and adapted from its primary function of cylindrical, liquid metal fast reactor fuel to include capabilities for many different fuel shapes and compositions. The facility has assisted in developing waste characterization technology as well as performing both destructive and non-destructive exams on many types and forms of research fuel.